A Usability Investigation of Parallax Scrolling for Web Pages

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Abstract. This paper presents an empirical investigation, concerning the usability of parallax scrolling for web pages. Parallax scrolling within a web page can be explained as usually having several backgrounds that move at different speeds. This creates a visual three-dimensional effect of motion. The main aim of the investigation was to try and gain further insights into whether using parallax scrolling would have a positive or negative effect on usability aspects, which in turn would affect end user experience. The data collected, were statistically analyzed using significance testing (T-test). The statistical analysis indicated that on average participants were faster with the non-parallax web site. Further, on average, participants indicated stronger preferences for the parallax web site. The significance testing indicated that there were no significant differences in total task completion time and total number of errors. Participants' opinions concerning the two web page styles also indicated no significant differences. Although this work does not present statistically significant results, it is still useful to the research community. The averages indicate tendencies which could be useful to web site designers for improving usability. Well known guides such as WCAG 2.2 and the Seven Universal Design principles give clear indication that in most cases parallax scrolling should be avoided and if it cannot be avoided there needs to be a clear and easy way for users to switch off the feature should they wish to do so.

Keywords: Parallax Scrolling · Usability · User experience · Evaluation · Web Page Design

1 Introduction

Designing software and web sites can be a creative activity where human imagination can be used to achieve user interfaces with varying styles and behaviors. However, a true professional will consider these aspects inextricably linked to usability. Within the usability engineering and human computer interaction sphere, it is accepted that how the human experiences such systems and user interfaces is paramount.

In recent times, the parallax scrolling technique is seen on some web sites. Parallax scrolling within a web page can be explained as usually having several backgrounds that move at different speeds. This creates a visual three-dimensional effect of motion. Typically, when a user scrolls, elements within the web page will move to some other position and this will occur at potentially differing speeds (Fu 2016).

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This paper's main aim is to try and gain further insights into whether using parallax scrolling would have a positive or negative effect on usability aspects, which in turn would affect end user experience. If usability were negatively affected, it could result in users being less efficient and if user experience were negatively affected, users might not enjoy their journey through the web site. Each of these could result in users abandoning the use of a certain web site or perhaps making more errors. Web sites should foster efficient use and enjoyment within their respective contexts. Certain previous works have been potentially inconclusive due to either methodological aspects or results not showing any difference between parallax web pages and traditional web pages. For these reasons further work is required to fully understand the good and bad points of parallax scrolling, especially as it is a feature that is quite common in web site design.

We therefore present the details and results of an empirical investigation into the use of parallax scrolling on web pages. In the sections that follow we will highlight some background work. This will be followed by the details of an empirical experiment. Then the results from the data collected will be presented. Finally, the paper will conclude with a discussion and conclusions.

2 Background

One work by Fu (2016) compared two different user interfaces in the context of address books. One was under the Android operating system, while the other was under the Windows operating system. The Windows based address book used parallax effects, while the Android one did not. Although their results indicated that the parallax-based address book incurred the most errors and slowest task times, we would suggest that the results could also be influenced by the two different platforms. Furthermore, although the participants were experienced IT users, nothing is said about their experience with Android and Windows.

In another work (Frederick et al. 2015) no significant difference was observed when parallax-based web pages were compared with non-parallax-based web pages. This was for aspects of 'perceived usability, enjoyment, satisfaction, and visual appeal'. However, the parallax-based condition was perceived to be significantly more fun than the non-parallax-based web pages. This study had an impressive large sample size of participants, but the study did not consider effectiveness issues in the use of web pages. It was also interesting to note that a small number of participants experienced motion sickness (related to using parallax-based web pages) whilst taking part in the study.

Also, a study by Mahardika et al. (2018) investigated parallax scrolling in the context of storytelling and online shopping. Their results suggested that web pages designed with parallax scrolling led to faster task times and more participant engagement. However, the caveat to this was that the findings apply more to web pages that are heavily textual in nature and goal oriented. Further, the study employed a between-users set up and while some description of the participants is given, it is not clear if there was any bias (Lazar et al. 2017) in participant characteristics and experience which could have affected the results.

Recently, Karampournioti and Wiedmann (2022) looked at the effects of parallax scrolling and storytelling in an online shop context. They compared a version of a web

site with parallax scrolling and an alternative version containing text and images. Their overall general findings were that their participants felt enhanced user experience 'on explicit and implicit information processing levels'. The web site with parallax scrolling was also perceived as being more attractive. However, while the authors refer to the main work as an experiment, their two screenshots of the two web sites could indicate that other factors could have affected the results. The authors state that the information was the same for both web sites. However, from the screenshots provided other things between the two web pages were different, e.g. some of the images used differed as did the background design and colors. These are all aspects that could introduce bias into the results. Further, the study used a between-users experimental design, which could also introduce bias (Lazar et al. 2017) if not enough is known about the participants' background and experience (although this was slightly mitigated by the good sample size). The paper does not give enough detail on these two example aspects. Therefore, the sample used could also be a source of bias in the results.

Sherwin (2019) presents a series of issues suggesting that parallax scrolling negatively affects usability. Although this is discussed in relation to certain good practice tips for making parallax designs work better. This suggests that fine tuning a parallax design can make or break the usability aspects.

As can be seen from the above consideration of some relevant previous works, the picture concerning parallax scrolling and its effectiveness and effect on user experience is not categorically clear. Some previous works indicate issues in methods and contexts used.

In the next section we present the details of an empirical experiment comparing parallax web pages with non-parallax web pages.

3 The Evaluation

For this work an empirical experiment was chosen for the evaluation. Previous literature (see previous section) indicates that this is a suitable option and it also fits with our wish to be able to tightly control aspects that are more easily achieved with an experiment.

The experiment described in this paper centered around the two main areas of performance and user experience. Linked to these two main hypotheses were selected:

- H1: There will be a statistically significant difference between scrolling methods for performance.
- H01: There will be no statistically significant difference between scrolling methods for performance.
- H2: There will be a statistically significant difference between scrolling methods for user experience.
- H02: There will be no statistically significant difference between scrolling methods for user experience.

3.1 Experimental Design

The experiment used a within-users experimental design. The main reason for this was that we wished participants to experience both kinds of interaction and then be able to have comparative thoughts about parallax scrolling and non-parallax scrolling.

3.2 Users

In this study, 6 participants of varied ages took part in the experiment. Participants were asked to give some indication of their computer experience and awareness of certain concepts. The responses summarized in Table 1 suggest that the small sample used had good general computer experience and awareness of concepts related to the topic of study covered in this paper.

Table 1. Summary of Participant Characteristics

Participants Characteristics in Percentages	
Education	Graduate: 100%
Profession	Student: 50%
	Other: 50%
Years of Computer Experience	2–5 years: 33%
	More than 5 years: 67%
Reason for Using the Internet	Email: 33%
	Web Browsing: 33%
	Research Study: 17%
	For Fun: 17%
Experience in Using Web Sites (Years)	Less Than 2 Years: 17%
	More than 5 Years: 83%
Type of Device Used for Web Browsing	Laptop: 67%
	Mobile: 33%
Frequency of Use of Scrolling Feature While Browsing Web Pages	Many times: 83%
	Sometimes: 17%
Has Experience in Using Animated Web Pages	Yes: 100%
Awareness of Parallax Scrolling	Yes: 33%
	No: 67%
Awareness of Universal Design	Yes: 67%
	No: 33%

3.3 Variables

For this experiment the independent variables were the two user interfaces and the tasks. The dependent variables were performance and user satisfaction. The dependent measures for the performance aspects were total task time and total number of errors. An error was counted when a participant unintentionally clicked somewhere during a task, when incorrect content was clicked on and when a counting mistake was incurred

during the first task (see the description of tasks for more detail on Task 1). The dependent measure for user satisfaction was via a post-experiment questionnaire, which covered aspects of the participants' experience in using the two web user interfaces.

3.4 Apparatus, Materials and Tasks

The following materials were used in this experiment:

- Lenovo legion 5 laptop with AMD Ryzen 5 4600H, Windows 10 OS, 16 GB RAM.
- Mobile Phone Stopwatch.
- Microsoft Edge web browser.
- Screen recorder.
- Consent form.
- Pre-experiment questionnaire.
- Tasks document needed for the experiment.
- Post-experiment questionnaire.

The web pages developed were in the context of a restaurant web site. To that end the tasks developed continued in this theme. These are detailed in Table 2.

Table 2. The Tasks Used in the Experiment

Task Group A	
Task Number	Task Details
1	Go to home page and count the number of vegetable food items
2	Find the information about the Restaurant on the home page
3	Fill the form on the takeaway page and order two vegetable food items and one drink. Select the option of home delivery as well
Task Group B	
Task Number	Task Details
1	Go to home page and count the number of non-vegetable food items
2	Find the email address of the restaurant on the home page
3	Fill the form and order two non-vegetable items and one drink with the option of home delivery from the takeaway page

Figures 1 and 2 show the main elements of the web site that was designed. Both versions were identical, however one used the parallax scrolling concept, while the other did not (Note: it is not possible to show statically via images the parallax effect).

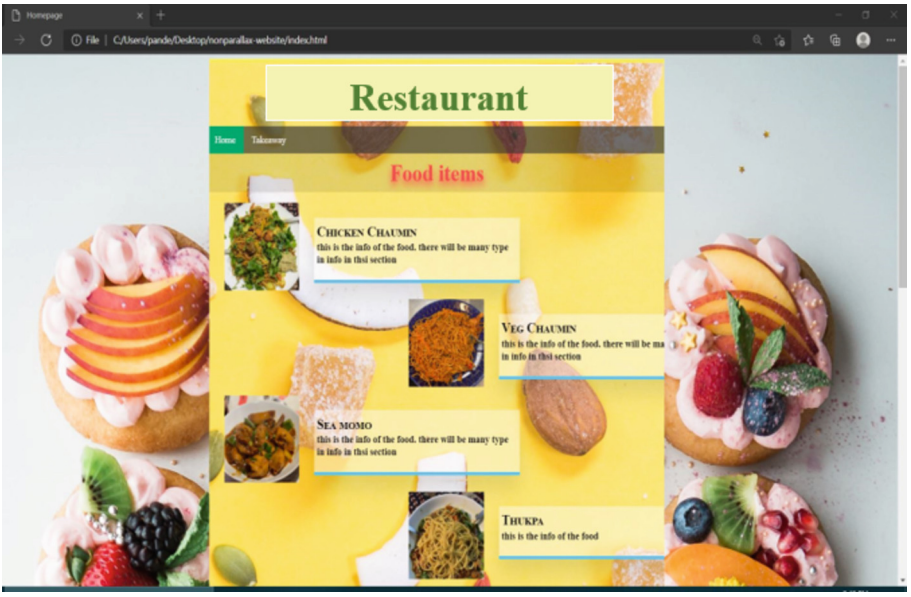

Fig. 1. Homepage

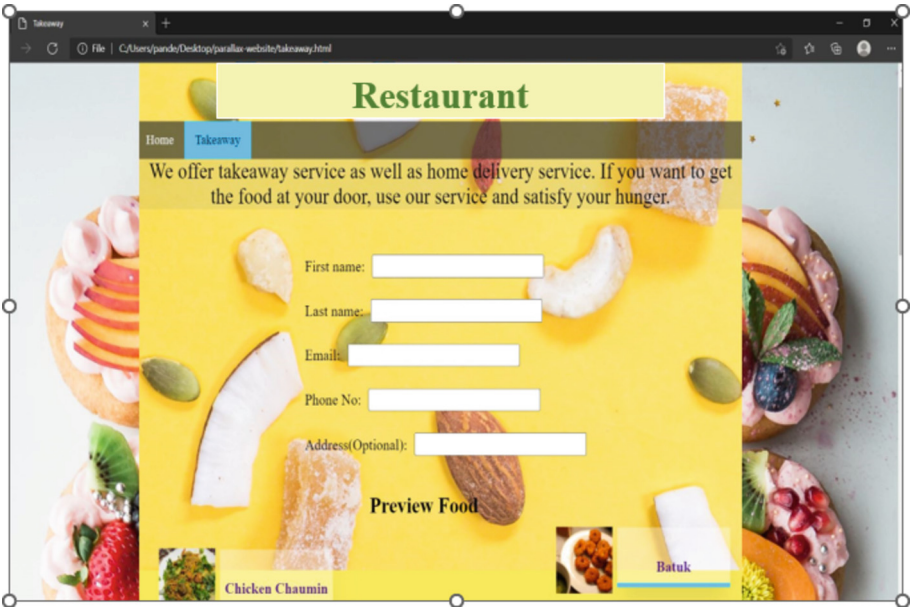

Fig. 2. Food Takeaway Page

3.5 Procedure

A procedure was designed for the experiment which was followed with all the participants. The first part of the experiment involved participants reading pre-prepared information about the experiment and process and then giving consent if they were in agreement. The whole experiment followed Norwegian requirements for ethics in research studies of this kind. Having completed the consent aspects, participants were then asked to complete a questionnaire that elicited a few aspects concerning their background experience.

When the questionnaire was completed, the participants were given information about the procedure that would be followed and the tasks they would carry out.

Then using the two prototype web sites the participants carried out the tasks detailed in Table 2. The usage of the tasks in relation to the parallax and non-parallax web pages was as detailed in Table 3.

Table 3. Tasks and Web Page Type Order of Execution

Participant Number	Web Site	Task Group	Web Site	Task Group
1	Parallax	A	Non-Parallax	B
2	Non-Parallax	B	Parallax	A
3	Parallax	B	Non-Parallax	A
4	Parallax	A	Non-Parallax	B
5	Non-Parallax	B	Parallax	A
6	Parallax	B	Non-Parallax	A

As the experiment proceeded, any questions asked by participants concerning the tasks, were dealt with by giving small hints to allow for progress through the experiment.

As a conclusion to the experiment, participants were subsequently asked to complete a post-experiment questionnaire. This concerned aspects of their experience with the two web user interfaces.

3.6 Results

The data collected was analyzed and the initial exploration showed the data to be parametric in nature (actual results for this aspect are not included for brevity). It was therefore decided to use a t-test for each pair of data.

For the total time to complete the tasks, the parallax scrolling incurred a Mean (M) time of 145.83 s with a Standard Deviation (SD) of 48.72. The non-parallax scrolling incurred a Mean time of 137.33 s with a Standard Deviation of 76.62. The paired t-test result is $t(5) = 0.276$, $p = .794$ (two-tailed). Therefore, the result suggests a lack of a significant difference. The means suggested that the non-parallax scrolling method was a little faster for task completion time.

For errors, we do not present significance testing as both scrolling methods incurred equal means in terms of amounts of errors (M = 1.167 for both). Further, for each condition, the standard deviations were comparably low (SD = 1.3292 Parallax Scrolling, SD = .7528 Non-Parallax Scrolling).

Each post-experiment question from the questionnaire was also analyzed. The questionnaire contained eight questions answered by participants using a 5-point Likert-type scale (Likert 1932). The scale ranged from 1 – Strongly Disagree to 5 – Strongly Agree. Four questions elicited opinions about the tasks and the web page designs used. These aimed to give some confidence that the whole context of the experiment in relation to the tasks and web page designs appeared acceptable to the participants. As can be seen in Fig. 3, these aspects were all rated very positively and consistently.

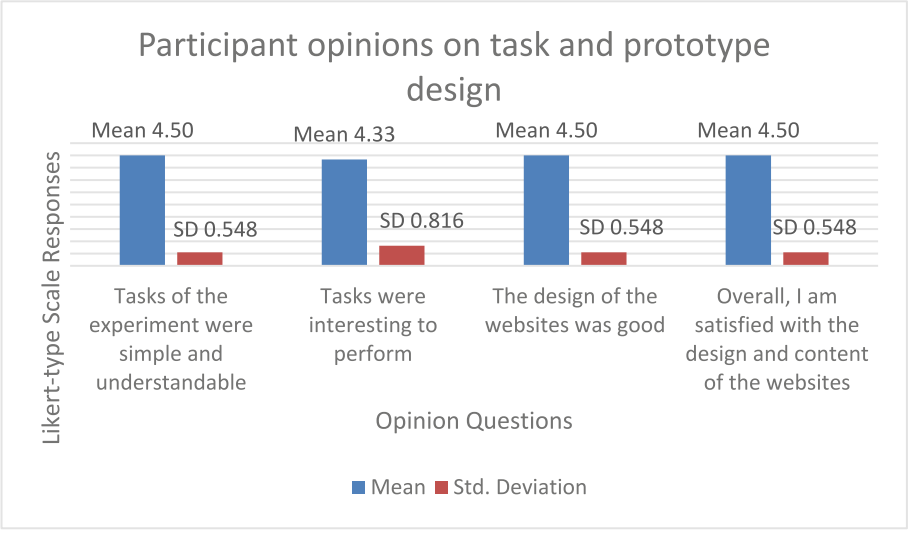

Fig. 3. Participant Opinions on Task and Prototype Design

The remaining four questions were more specifically about the comparison of parallax scrolling and non-parallax scrolling. Using the same scale as described, each question was answered two times. Once in relation to each scrolling method. Therefore, this allowed participants to select scores for each in a comparative manner.

For the question asking participants to rate their level of interest while scrolling through the content of the web site, the results were as follows: The parallax scrolling incurred a Mean (M) score of 3.67 with a Standard Deviation (SD) of 1.211. The non-parallax scrolling incurred a Mean score of 3.17 with a Standard Deviation of 1.169. The paired t-test result is $t(5) = 0.808$, $p = .456$ (two-tailed). Therefore, the result suggests a lack of a significant difference. The means suggested that the non-parallax scrolling method was rated slightly less interesting than the parallax design.

For the question asking participants to rate how pleasant it was to scroll through the content of the web site, the results were as follows: The parallax scrolling incurred a Mean (M) score of 3.83 with a Standard Deviation (SD) of 1.169. The non-parallax

scrolling incurred a Mean score of 3.33 with a Standard Deviation of .816. The paired t-test result is $t(5) = 0.745$, $p = .490$ (two-tailed). Therefore, the result suggests a lack of a significant difference. The means suggested that the non-parallax scrolling method was rated to be slightly less pleasant than the parallax design.

For the question asking participants to rate how confident they felt whilst carrying out the tasks, the results were as follows: The parallax scrolling incurred a Mean (M) score of 4.00 with a Standard Deviation (SD) of .894. The non-parallax scrolling incurred a Mean score of 3.67 with a Standard Deviation of 1.033. The paired t-test result is $t(5) = 1.00$, $p = .363$ (two-tailed). Therefore, the result suggests a lack of a significant difference. The means suggested that the non-parallax scrolling method fostered potentially less confidence in the participants.

For the question asking participants to rate their level of preference of the scrolling methods, the results were as follows: The parallax scrolling incurred a Mean (M) score of 4.00 with a Standard Deviation (SD) of 1.26. The non-parallax scrolling incurred a Mean score of 3.33 with a Standard Deviation of .816. The paired t-test result is $t(5) = .877$, $p = .421$ (two-tailed). Therefore, the result suggests a lack of a significant difference. The means suggested that the parallax scrolling method was preferred slightly more over the non-parallax design.

Having presented the analysis of the results, the next section concludes this paper with a discussion and conclusion.

4 Discussion and Conclusions

The investigation aimed to explore aspects of performance and subjective preferences concerning parallax scrolling and non-parallax scrolling. Our data collection and subsequent analysis suggests that performance in terms of task time and errors is not significantly affected by the scrolling methods we implemented. Subjective opinions were also not significantly affected by the scrolling method. In terms of the experiment and the associated hypotheses presented in this paper, we accept the outcomes as being in line with the null hypotheses presented earlier.

However, the data showed slight trends in a certain direction. The task time data showed that the non-parallax version was quicker to use, although the small data set was not so consistent having high standard deviations. The four subjective comparative questions posed to the participants showed a slight overall preference for the parallax-based version of the web site we implemented. In these cases, all indicated a more consistent level of opinion, where each had low standard deviations.

Certain standard guidelines suggest that parallax scrolling should either be avoided or be implemented in such a manner that it can be controlled or switched off at will by a user. The Web Content Accessibility Guidelines (WCAG) 2.2 in section 2.3.3 (W3C, 2023) suggest implementations that allow 'motion animation triggered by interaction' to be switched off. The exception to this is if the animation itself is a complete requirement in terms of some functionality or that the information itself needs such an animation. Further, the WCAG 2.2 Understanding Docs, Understanding SC 2.3.3: Animation from Interactions (Level AAA) (W3C 2024), gives further information on the negative aspects of parallax scrolling. In line with the nausea observations made by Frederick et al.

(2015), mention is made that animations can cause nausea and migraine headaches. Parallax scrolling is specifically mentioned in (W3C 2024) as being a potential problem, particularly if there is no option to switch off the feature.

The aspect of parallax scrolling can also be looked into in light of the well-established principles of universal design (Story 1998). If a designer or developer implements parallax scrolling that cannot be switched off and for no particular reason other than it may be considered to be 'nice' or 'cool', then this approach may go against the universal design principles. For example, Principle 1 is about 'Equitable Use' and Principle 1b concerns avoiding 'segregating or stigmatizing any users' (Story 1998). If parallax scrolling causes nausea or headaches in some users, then it clearly stigmatizes some users and should not be used or at the very least should be easily turned off. Principle 2 is about 'Flexibility in Use' and Principle 2a says to 'Provide choice in methods of use (Story 1998).' Clearly if users are forced to use parallax scrolling that in many cases is unnecessary, then such an implementation does not provide a choice for end-users. Principle 6 is about 'Low Physical Effort' (Story 1998). It should be clear that an interaction method that can create in users' nausea and headaches is not fostering lower physical effort in using the web site.

Overall, our work did not present any categorical results. The results we did obtain, could be referred to as being a hint in a certain direction, where for performance aspects it might be better to have no parallax effects. However, participants tended to prefer the parallax effect in the web site.

Established guidelines suggest more strongly that parallax effects should not be used. If parallax effects are used, they should either be essential to something on the web site or in all or most cases there must be the option to switch off the feature in an easy and quick manner.

In future work it would be good to address the limitations of this research. We had two potential issues. The first was a rather small sample size. The second was that perhaps the web pages designed did not foster complex enough tasks to really bring out any potential differences in interacting with or without the parallax effects. Another aspect difficult to implement in this kind of research is the long-term use of a web site with parallax effects. It could be that participants' opinions change over time or become stronger towards a certain direction over time. Also, when the initial novelty feeling wears off, this can be a cause for a change in opinion.

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